Photovoltaics manufacturing: Lessons to learn and unlearn from the semiconductor industry

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The last 10 years have seen the photovoltaics (PV) industry grow from ~0.5 GW to 30 GW in scale. In semiconductor industry terms, the PV industry now ships an area equivalent to around 50 million wafer-starts per week. To finance this growth, the PV industry must fund capacity expansions with either debt or cash from operations. As average selling prices have collapsed in the 2012 PV market, this goal has become extremely challenging. The industry needs a significant technical redirect in order to achieve its potential long-term impact on the climate.

The PV industry has always required capital expenditures (CapEx) to be a fraction of those in the semiconductor business (per m^2 but also as a %-of-revenues). First Solar's approach to this challenge has been to use processes and metrologies adapted from glass manufacturing and other low-cost/m^2 industries, while adopting statistical process control methodologies from the semiconductor industry. This leads to tight process control and rapid replication but with extremely low CapEx/W; at $0.65/W, First Solar is still the leader in the industry. The CapEx/gross margin ratio is crucial for growth. When First Solar initially launched in 2006, the high average selling prices sustained margins that allowed the company >100% compound annual growth rate (CAGR) based on cash from operations. The CapEx levels elsewhere in the PV industry were significantly higher, but still sustained healthy levels of growth from cash-flows. More recently, however, following massive overinvestment in China and the resulting price collapse, the industry has become more like the DRAM arena. Current industry projections indicate gross margins at a level that is inadequate to support further capital growth except through debt or government financing. At free-cash-flow growth levels, the industry cannot grow fast enough to significantly impact global energy supply. In addition, the crystalline Si technology that dominates in China has a suboptimal carbon footprint and is a major consumer of coal-fired electricity. A new cycle of innovation is required to break out of the present cycle of high-emissions solar with profitless market-share.